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A systematic review of child passenger safety laws and their associations with child restraint system use, injuries, and deaths

Emma B. Sartin<sup>\*1</sup>, Leah R. Lombardi<sup>1</sup>, Jessica H. Mirman<sup>2</sup>

1. Center for Injury Research and Prevention, The Children's Hospital of Philadelphia, Philadelphia, PA
2. University of Edinburgh, Department of Clinical and Health Psychology, Centre for Applied Developmental Psychology, School of Health in Social Science

\*Corresponding Author:

Emma B. Sartin

[sartine@chop.edu](mailto:sartine@chop.edu)

Center for Injury Research and Prevention

The Children's Hospital of Philadelphia

2716 South Street, Philadelphia, PA 19146

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## **ABSTRACT**

*Background and Objective:* Many countries and all U.S. states have legislation that mandates how children of certain ages and/or sizes should be restrained in vehicles. The objective of the current systematic review was to describe the associations between legislation and three outcomes: child restraint system use, correct child restraint system use, and child passenger injuries/deaths.

*Methods:* Included studies were published between 2004-2020 and evaluated associations between child passenger safety laws and the outcomes described above. Three literature searches using three search terms (child passenger safety, car seat use, booster seat use) were completed in PubMed and PsychInfo, with the last search occurring in January 2021. Studies are presented based on the outcome(s) they evaluated. The original protocol for this review is registered with PROSPERO (ID: CRD42019149682).

*Results:* Nineteen studies from 5 different countries evaluating a variety of different types of legislation were included. Overall, positive associations between legislation and the three outcomes were reported. However, there were important nuances across studies, including negative associations between booster seat legislation and correct child restraint use. Further, there were also negative associations between various types of legislation and outcomes for populations with less formal education and lower incomes, and for racial and ethnic minorities.

*Conclusion:* Overall, child passenger safety legislation appears to be positively associated with child restraint system use, correct child restraint use, and child passenger injuries/deaths. However, there is a need to more comprehensively characterize how different types of legislation influence child passenger safety outcomes to promote equitable effects across populations.

*Key words:* legislation, systematic review, motor vehicle occupant, child

***What is already known?***

-In the past several decades, many countries and all U.S. states have enacted various types of child passenger safety laws.

-There is currently no review of studies evaluating associations between child passenger safety legislation and child restraint use, correct child restraint use, or child passenger injuries and fatalities.

***What this study adds:***

-Overall, legislation is associated with positive child passenger safety outcomes; however, important nuances exist, especially for how legislation may influence correct or appropriate restraint use or restraint use among at-risk populations.

-There is a need for studies that more closely evaluate what types of legislation produce the most equitable results across populations.

## INTRODUCTION

Despite substantial reductions over the last several decades, motor vehicle crashes remain a leading cause of injury and death for children less than 15 years old.<sup>1</sup> One way to reduce children's risk of being injured or killed in a crash is by restraining them in child restraint systems (CRS), or car seats and booster seats.<sup>2,3</sup> However, despite the effectiveness of CRS and decades of awareness and intervention efforts, the majority of caregivers either do not use a CRS and/or continue to misuse them (i.e., they do not use the CRS correctly according to best practice, legislation mandates, or the manufacturer's guidelines). This is especially true within racial and ethnic minority families (e.g., Black and/or Hispanic/Latino), who—compared with their White peers—remain much less likely to use any CRS,<sup>4</sup> are up to three times more likely to misuse a CRS,<sup>5</sup> and are up to twice as likely to be killed in a crash.<sup>1</sup>

To improve CRS awareness, uptake, and use, many countries and all states and territories in the United States currently have some type of child passenger safety legislation. Importantly, there have been no recent attempts to review studies evaluating the effects of these various policies. Understanding the association between legislation and CRS behaviors and crash outcomes, as well as how these associations vary across populations, can inform the development or adaptation of future policies and is therefore a critical step in further reducing the burden of motor vehicle crashes on children worldwide. With this in mind, the objective of the current systematic review was to identify and characterize studies evaluating the effects of different child passenger safety policies. More specifically, we identified and characterized studies published between January 1, 2004 and December 31, 2020 that examined legislation's impact on three outcomes: (1) CRS use, (2) correct or appropriate CRS use, and (3) crash injuries and fatalities.

## METHODS

### *Search and Screening Process*

The original protocol for this review is registered with PROSPERO (ID: CRD42019149682). To be included, studies had to assess the impact of legislation on at least one of three outcomes: CRS use, correct or appropriate CRS use, and crash injuries and/or fatalities. All results related to each of these outcomes, including those within studies assessing multiple outcomes, were included in this review. Literature searches were conducted in PsycINFO and PubMed and restricted to studies published between January 1, 2004, and December 31, 2020. The initial search and screening process was completed between May 25, 2018, and April 1, 2019, and is described in a different systematic review of CRS interventions.<sup>6</sup> In this initial search, 3 reviewers completed literature searches in each database, using the following search strings: (1) *child passenger safety*, (2) *booster seat use*, and (3) *car seat use*. In PsycINFO, searches were restricted to peer-reviewed articles with an age group criterion of childhood (birth to 12 years). In PubMed, searches were restricted to human species and an age group criterion of birth to 18 years. Any identified articles that were literature reviews were examined to ensure that all articles possible were found and included in this analysis. All search result references were downloaded and entered into an Excel file that included detailed information about the study's aims, outcomes, participant population, findings, and a "relevancy" score determined by the reviewer (1 = extremely relevant, 2 = maybe relevant, and 3 = not at all relevant). A total of 1,240 abstracts were found; however, after the initial review of abstracts for relevancy and duplicates, and further examining articles deemed "extremely" or "maybe" relevant, only 17 articles focused on child passenger safety legislation were included in this review.

A second literature search completed independently by the second author to update and supplement the first search was conducted in PubMed during July and August 2020. This search looked for studies published since the completion of the first search (i.e., after April 2019), used the same search terms as the original search, and restricted results to only include studies with an age group criterion of birth to 18 years. A total of 155 studies were located through this search; only 2 additional articles were relevant and included in this review. A final search (also conducted by the second author) using this same process was conducted in January 2021 and identified 62 potential studies; however, none were deemed relevant or added to this review. Therefore, 19 studies were included in this systematic review (Table 1): Gunn et al. (2007), Winston et al. (2007), Pressley et al. (2009), Snowdon et al. (2009), Brixey et al. (2010), Sun et al. (2010), Brixey et al. (2011), Eichelberger et al. (2012), Mannix et al. (2012), Brown et al. (2013), Keay et al. (2013), Koppel et al. (2013), Simniceanu et al. (2014), Violano (2015), Yanchar et al. (2015), Nazif-Muñoz et al. (2017), Singh et al. (2019), and Martínez et al. (2020). Originally, we sought to also complete a meta-analysis and assess each study for bias; however, the majority of studies were pre-post designs, and very few presented their data or conducted their evaluations according to the standards outlined by Cochrane, limiting the utility or informativeness of any results produced. Therefore, we opted not to proceed with the meta-analysis or risk of bias assessment, and instead focused on providing more details of each study included in this systematic review. With these exceptions in mind, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>7</sup> Patients and the public were not involved in any aspect of this systematic review.

## **RESULTS**

### *Included studies*

Figure 1 depicts the search and screening process. Nineteen studies from 5 different countries (United States, n=9; Australia, n=3; Canada, n=4; Chile, n=2; and New Zealand, n=1) were included in this review. As shown in Table 1, outcomes measured across the studies (with some assessing multiple outcomes) include the effect of legislation on overall rates of CRS use (n=9), correct/appropriate CRS use (n=10), and rates of child passenger crash injuries and/or fatalities (n=6).



Table 1. Characteristics of included studies

Study	Study Design	Country	Outcomes evaluated (method used to collect data or data source)	Study notes
Gunn et al. (2007)	Pre-post	U.S.A.	Correct CRS use (observations)	Law added requirements for booster seat use for child passengers 4-8 years old in Tennessee, U.S.A. Reported different effects by race/ethnicity
Winston et al. (2007)	Pre-post	U.S.A.	Correct CRS use (caregiver self-report)	Study compared restraint use in children from multiple states involved in crashes via insurance claims and a telephone survey
Pressley et al. (2009)	Cross-sectional comparison	U.S.A.	Injuries (Kids Inpatient Database)	Compared injury rates for child passengers 3-8 years old in states with and without booster seat laws. Study reported income and racial disparities, suggesting legislation is not a “universal” intervention
Snowdon et al. (2009)	Cross-sectional comparison	Canada	CRS Use (roadside observation surveys)	Compared restraint use among 4- to 8-year-olds in Canadian provinces with and without booster seat laws. Reported more restraint use in provinces with laws than those without, however rates were still very low regardless of laws, suggesting the need for supplemental education and awareness efforts
Brixey et al. (2010)	Pre-post	U.S.A.	CRS Use (caregiver self-report), Correct CRS Use (caregiver self-report)	Evaluated a modified law that mandates CRS use for children up to 8 years old. Post-law, fewer children were unrestrained, no significant increases in correct restraint use. Poor, urban children were more likely to be prematurely transitioned to booster seats
Sun et al. (2010)	Pre-post	U.S.A.	Injuries (NYS Department of Motor Vehicles Accident Information System)	Evaluated an upgraded child restraint law in New York State requires CRS use for children < 7 years old. Injuries among children in the age group targeted by new booster mandates decreased; no decreases observed for children less than 4 years old
Brixey et al. (2011)	Pre-post	U.S.A.	CRS Use (observations), Correct CRS Use (observations)	Evaluated a modified law that mandates CRS use for children up to 8 years old (same law as Brixey 2010) with a focus on the law’s impact on different populations. Overall CRS use increased; however, correct use only increased in White populations. Income was associated with overall use but not correct use.
Eichelberger et al. (2012)	Pre-post comparison of states with booster seat laws	U.S.A.	CRS use (police reported crash data), Injuries (police-reported crash data)	Compared use of restraints and injury rates among booster-age child passengers involved in crashes pre-post booster seat laws. CRS use increased nearly 3-fold; injuries and fatalities significantly decreased post-legislation

Mannix et al. (2012)	Pre-post comparison of states with booster seat laws	U.S.A.	CRS use (FARS), Fatalities (FARS)	Compared use of restraints and fatalities among 4-5-, 6-, and 7-year-old passengers across states. Laws increased CRS use and decreased fatalities
Brown et al. (2013)	Pre-post	Australia	Correct CRS use (observations)	National law mandates children < 7 must be in a CRS. Examined appropriate CRS according to law and correct use according to CRS instructions (e.g., installation). Appropriate use according to law increased by 2.3 times; correct use increased by 1.6 times
Keay et al. (2013)	Pre-post	Australia	Correct CRS use (observations)	National law mandates children < 7 must be in a CRS. Age appropriate CRS use increased post-legislation; age-based differences were detected
Koppel et al. (2013)	Pre-post	Australia	Correct CRS use (observations)	National law mandates children < 7 must be in a CRS. No differences in correct CRS use pre-to-post legislation. This study observed actual installations in addition to child age and CRS fit
Simniceanu et al. (2014)	Pre-post	Canada	CRS use (observations), Correct CRS use (observations)	Compared outcomes across provinces with and without legislation. Increased CRS use and appropriate CRS use for 4-to-8-year-olds post legislation
Violano (2015)	Pre-post	U.S.A.	CRS use (state crash database)	Evaluated a strengthened child passenger safety law enacted in 2005. Children were 1.3 times more likely to be restrained in a CRS post-law
Yanchar et al. (2015)	Pre-post	Canada	CRS use (caregiver self-report)	Telephone survey of caregivers pre- and post- updated car seat and booster seat laws. Increased CRS use for car seats and booster seats post-legislation
Nazif-Muñoz et al. (2017)	Pre-post	Chile	Injuries (administrative data sources), Fatalities (administrative data sources)	Legislation only focused on CRS use for children < 3 years old. Examined injury and fatality rates from 2000-2012, with national legislation enacted in 2005. Legislation was associated with a 35% reduction in injuries in the short term; effects diminished over time. No significant evidence legislation influenced fatalities
Singh et al. (2019)	Pre-post	New Zealand	CRS use (caregiver self-report)	Law mandates children < 7 must be in a CRS. Compared with data collected in an earlier study, restraint use increased post-legislation
Martínez et al. (2020)	Pre-post	Chile	Fatalities (administrative data sources)	Legislation only focused on CRS use for children < 3 years old (same law as Nazif-Muñoz et al., 2017); included a wider age range and found overall decrease in fatality rates for child passengers

### *The Impact of Legislation on Rates of Child Restraint System Use*

We identified 9 papers that examined associations between legislation and overall rates of CRS use, or the number of children restrained in any CRS (regardless of accuracy). CRS use was measured using self-report methods (Brixey et al., 2010; Singh et al., 2019), fatal and non-fatal crash report data (Mannix et al., 2012; Sun et al., 2010; Eichelberger et al., 2012; Violano (2015), and observations (Snowdon et al., 2009; Brixey et al., 2011; Simniceanu et al., 2014).<sup>8-16</sup>

Multiple studies have reported increased rates of CRS use following new legislation in the U.S. First, Sun et al. (2010) analyzed data from the New York State Accident Information System between 2003-2007 and found a 72% increase in CRS use among 4- to 6-year-old passengers pre-to-post-legislation (legislation change was enacted in 2005). Similarly, Eichelberger et al. (2012) conducted a pre-post study of five states who enacted new booster seat laws and reported a nearly 3-fold increase in the number of children restrained in any type of CRS, while Violano (2015; a dissertation made available by Walden Dissertations and Doctoral Studies Collection at ScholarWorks) reported children in Connecticut were 1.3 times more likely to be restrained following the state's strengthening of child passenger safety and CRS use laws in 2005. In two studies, Brixey et al. (2010 & 2011) reported fewer children in Wisconsin were traveling unrestrained following booster seat legislation enacted in 2006; however, they noted important caveats about how legislation impacted appropriate CRS use (described below). Lastly, Mannix et al. (2012) examined rates of booster seat use among child passengers in the Fatality Analysis Reporting System (FARS) between 1999 (before any states enacted booster seat legislation) and 2009 (post-booster seat legislation), while controlling for temporal and socioeconomic factors. By

age, booster seat use among fatally injured children increased from 9% to 41% among 4- to 5-year-olds, from <0.9% to 23% among 6-year-olds, and from 0.1% to 12% among 7-year-olds.

Legislation has also had positive associations with rates of CRS use in other countries. In New Zealand, Singh et al. (2019) conducted a survey of restraint use within pediatric inpatients and found that a larger proportion of children were restrained than what was reported before new age-and-CRS-type mandates were introduced. In Canada, Snowdon et al. (2009) reported that 24.6% of 4- to 8-year-old children in Canadian provinces covered by booster seat legislation were restrained compared with only 16.6% in provinces without similar legislation; several years later Simniceanu et al. (2014) reported that overall CRS use was higher among 4- to 8-year-olds in Canadian provinces with legislation than those without.

#### *Correct Use*

Ten studies examined the association of legislation with correct or appropriate CRS use, defined as one or more of the following (depending on the study): 1) the CRS use is correct based on child-seat fit mandates established by legislation or best practice, 2) the actual use of the CRS is accurate (e.g., child is correctly harnessed into seat), and 3) the CRS is correctly installed into the vehicle. In these studies, appropriate CRS use was measured using caregiver self-report (Winston et al., 2007; Gunn et al., 2007; Brixey et al. 2010; Keay et al., 2013; Yanchar et al., 2015) and observations (Snowdon et al., 2009; Brown et al., 2013; Koppel et al., 2013; Simniceanu et al., 2014; Brixey et al., 2011).<sup>8,14–22</sup>

The majority of studies examining the association of legislation with appropriate CRS use reported positive findings, most notably in booster seat use. Before and after the enactment of enhanced child passenger safety legislation in Nova Scotia, Canada, Yanchar et al. (2015) conducted telephone surveys with caregivers of children less than 12 years old and found that

appropriate use of forward-facing car seats increased from 74% to 92%, while correct booster seat use increased from 58% to 95%. Also in Canada, Simnieceanu et al. (2014) completed roadside observations and reported that provinces with specific booster seat legislation had higher rates of correct restraint use among 4- to 8-year-old child passengers than provinces without legislation (Simnieceanu et al., 2014). Similarly, Winston et al. (2007) compared insurance claims and caregiver self-reports across multiple states in the U.S. and found that 4- to 7-year-olds were 39% more likely to be appropriately restrained in states with booster seat legislation than in states without booster-specific legislation.

Several studies in Australia have also reported positive associations between appropriate CRS use and legislation. In New South Wales, Australia, Brown et al. (2013) completed observations of child passengers aged 2-5 years-old at preschools and daycare centers in lower-socioeconomic (SES) communities before and after new age-based mandates. Compared with pre-legislation odds, the odds of children being appropriately restrained according to the legislation's age-based mandates were 2.3 times greater post-legislation, while the odds of children being correctly restrained according to manufacturers' instructions were 1.6 times greater (Brown et al., 2013). Similarly, Keay et al. (2013) conducted a survey with 1,160 caregivers of children aged 2-5 years enrolled at one of 28 early childhood centers in lower SES areas of metropolitan Sydney and found that overall, there was an improvement in appropriate CRS use based on children's age when compared with historic data; the authors concluded these improvements in appropriate CRS use indicated the new legislation produced a positive impact. However, this study also reported a low rate of age-appropriate restraint use in 3-year-olds, with nearly half prematurely transitioned to a booster seat or adult seat belt post-legislation. In addition, Koppel et al. (2013) analyzed multiple years of observational data collected both pre- and post-legislation (total observations=

2,674), mainly focusing on errors in child harnessing and the CRS's installation to the vehicle. They reported that 79% of the CRS inspections conducted post-legislation still had at least one error in use.

Importantly, several studies reported striking nuances in how legislation may be influencing correct CRS use among specific populations. While Brixey et al. (2010) and Brixey et al. (2011) found that booster-seat legislation in Wisconsin increased the overall number of children traveling in any type of CRS, Brixey et al. (2010) did not find meaningful differences in how many children 0–7 years old were appropriately restrained, and the majority of urban children remained inappropriately restrained post-legislation. In addition, Brixey et al. (2011) reported important racial and ethnic groups differences: White caregivers' proper booster use increased from 48% to 68%, Black caregivers' proper use dropped from 18% to 7%, and Latino caregivers' proper use rates were stable at 10%. Based on these findings, the authors concluded that while the booster seat legislation increased the overall number of children traveling in booster seats, it had null or potentially negative consequences for lower SES and racial/ethnic minority families' appropriate use, with many prematurely transitioning their young children to booster seats. Similarly, Gunn et al. (2007) completed community observations before and after Tennessee enacted an enhanced child safety restraint law in 2004 that included new requirements for booster seat use among 4- to 8-year-old passengers. The authors reported appropriate booster seat use increased from 29% pre-legislation to 39% post-legislation; however, Black child passengers did not have meaningful increases in booster seat use and remained twice as likely to be unrestrained than their White peers post-legislation. In addition, this study reported that booster seat legislation decreased appropriate CRS use for children younger than 4 years (i.e., encouraged premature transitions). Lastly, Snowdon et al. (2009) found that though the majority of Canadian children were restrained, only

about 60% were correctly restrained according to the child's height and weight and manufacturer's instructions. As a result of these nuances in appropriate CRS use post-legislation, many studies highlight the need for tailored, effective messaging and education to accompany changes made to existing or introductions of new child passenger safety legislation. More specifically, there appears to be a need for child passenger safety information to be disseminated in multiple languages and via different platforms (e.g., online, paper, in-person) to ensure accurate information reaches at-risk populations, particularly racial/ethnic minority and lower SES or income families.

### **Injuries and Fatalities**

We identified 6 papers that examined the association between legislation and rates of child passenger injury and/or fatality using national crash databases, fatality data, hospital discharge data, and hospital inpatient data (Sun et al., 2010; Eichelberger et al., 2012; Pressley et al., 2009; Nazif-Muñoz et al., 2017; Martinez & Contreras, 2020; Mannix et al., 2012).<sup>10–12,23–25</sup> With respect to crash-injuries, Sun et al. (2010) reported an 18% reduction in the traffic injury rate for children 4 to 6 years old following the implementation of legislation in New York focused on booster seat use; there were no pre-post legislation differences in the traffic injury rate of children < 3 years old (i.e., those not covered by the booster seat mandates). Eichelberger et al. (2012) evaluated similar booster seat-focused legislation across multiple states and reported a 5% reduction in the per capita rate of child passengers (of booster seat age, which varied by state requirements) who sustained any crash-injury (regardless of severity) and a 17% reduction in those who sustained fatal or incapacitating injuries. In addition, Eichelberger et al. (2012) also reported that 3- to 8-year-olds who were covered by booster seat legislation were less likely to be hospitalized for crash injuries than children in those states not covered by laws (i.e., children 9 to 12 years old). Similarly, using the Kids Inpatient Database, Pressley et al. (2009) found that children covered by booster

seat legislation were 22% less likely to be hospitalized for crash-injuries than children not covered. Importantly, this study found both income and racial/ethnic disparities, leading them to conclude that access to booster seats, quality of affordable seats, and proper use/enforcement strategies may impede the universal effectiveness of legislation.

Further, Martínez and Contreras (2020) conducted a pre-post study of legislation in Chile mandating seatbelt use for all passengers and CRS use for children under the age of 4 years. They reported the number of deaths for child passengers ages 0-14 years decreased from 1.71 deaths per 100,000 vehicles pre-legislation to 0.89 deaths per 100,000 vehicles post-legislation. However, Nazif-Muñoz et al. (2017) evaluated the same legislation's influence on the number of fatalities for child passengers ages 0-4 years and found that despite there being a 35% reduction in severe injuries only three years after implementation, there was no substantial difference in this age group's fatality rate (Nazif-Muñoz et al., 2017). The main difference between these studies is who was included in the analysis, with Martínez and Contreras (2020) incorporating a much larger age range, including adolescents who should be restrained in adult seat belts. In the U.S., Mannix et al. (2012) analyzed FARS data (controlling for SES and temporal factors) and found that states with booster seat laws had fewer child fatalities than states without booster seat laws. More specifically, states with booster seat legislation had adjusted incidence rates of 0.89 (95% CI= 0.81-0.99) for fatalities of 4- to 5-year-olds, while states with booster seat legislation that covered 6-year-olds had an adjusted incidence rate ratio of 0.77 (95% CI 0.65–0.91) for fatalities of 6-year-olds and those that included 7-year-olds had an adjusted incidence rate ratio of 0.75 (95% CI, 0.62–0.91) for fatalities of 7-year-olds.

## **DISCUSSION**



This is the first systematic review of studies evaluating associations between child passenger safety legislation and CRS use, correct CRS use, and child passenger injuries and fatalities conducted in the last 15 years. Overall, reviewed studies reported positive associations between legislation and these child passenger safety outcomes. Despite this overall trend, several studies reported important nuances in how legislation may influence behaviors in specific populations, especially those that are racial and ethnic minorities, lower-income, or have attained lower levels of education. In addition, there were multiple studies that reported important caveats about how legislation may impact correct CRS use specifically, with several warning that booster seat-specific legislation may prompt premature transitions for younger children. Lastly, there was a wide variety in the types of legislation and the methods used to evaluate each outcome. Taken together, these findings support the need for continued research on the effects of child passenger safety legislation. Specifically, future work must more clearly elucidate nuances in the effects of legislation across populations, with a particular focus on how child passenger safety laws influence lower SES and racial/ethnic minority populations' behaviors and outcomes. Our findings also underscore the need for initiatives and efforts that minimize adverse effects (e.g., premature booster seat transitions) to accompany legislation changes, implementations, and enforcements.

Strengths of this study include its rigorous search and screening methods and its international focus. However, the variability in study designs and the methods used to assess each legislation's impact do not allow for the authors to make any direct conclusions about the effect of legislation on different outcomes. For example, we were unable to compare differences in the impacts of legislation on CRS behaviors and injury outcomes based on whether studies utilized observational or self-report methodologies; this factor was a moderator of caregiver-targeted CRS interventions' effect sizes in a recent meta-analysis.<sup>6</sup> Thus, the reported effect sizes described this

review were likely influenced by how the study measured CRS behaviors and crash injuries/fatalities. To ensure accurate conclusions about how efforts like legislation influence real-world outcomes, child passenger safety researchers and stakeholders must improve the rigor and reliability of CRS-related data. One way to do this includes bolstering the accuracy and level of detail collected from crash reports (e.g., include more specific information about the CRS's installation/type, the child's weight/height, etc.). Additionally, in this review we were unable to determine how differences in legislation enforcement (i.e., primary versus secondary laws) influence reported associations. Further, all studies included in this review are from developed countries; more information on what legislation exists in less developed countries—as well as how legislation affects child passenger safety outcomes—are needed. Moving forward, there is a need for a comprehensive meta-analysis to determine what types of legislation are most effective. Doing so will allow researchers to not only directly compare how different types of child passenger safety laws influence various outcomes, especially across populations or communities, but also inform the development or adaptation of laws to support equity in transportation.

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